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# A study of the ability of deaf children in grouping, accentuation, and phrasing of movements of the individual speech organs versus syllables.

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# A STUDY OF THE ABILITY OF DEAF CHILDREN IN GROUPING, ACCENTUATION, AND PHRASING OF MOVEMENTS OF THE INDIVIDUAL SPEECH ORGANS VERSUS SYLLABLES

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by

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# A STUDY OF THE ABILITY OF DEAF CHILDREN IN GROUPING, ACCENTUATION, AND PHRASING OF MOVEMENTS OF THE INDIVIDUAL SPEECH ORGANS VERSUS SYLLABLES

By Ciwa Griffiths

## I. INTRODUCTION

Teaching speech to the deaf has a long history. But the problem of teaching deaf children to speak intelligibly has not been fully solved.

The accuracy of the reproduction of the individual sounds, or elements, has been the criteria by which teachers have been guided. Yet Bell (1) who was himself an ardent advocate of this "accuracy" came to the conclusion that "Ordinary people who know nothing of phonetics or elocution have difficulty in understanding slow speech composed of perfect elementary sounds, while they have no difficulty in comprehending an imperfect gabble if only the accent and rhythm are natural."

With "accuracy" as a criteria, the deaf child is taught, for instance, the consonants b and s as "bu" and "ssssss", and the vowels a and ee as "aaaaaa" and "eeeeee". Thus each sound is taught as a separate element. When these sounds are later combined to make syllables and words, the individual sounds retain their original quantity and quality making speech slow and

somewhat distorted. Such a word as "baby", for instance, becomes "ba-cbeeeeee". At the end of a word, b becomes "bu" as in "rubu" for "rub".

Deaf children, as a rule, do not readily learn the normal rhythms of English speech. The lack of intelligibility in the speech of the deaf child is due, in part, to a lack of syllable grouping, accentuation, and phrasing. Deaf children have not lacked "rhythmic training" in their education. They have been taught to accentuate and group dance steps, to clap their hands in accented and unaccented movements, and to beat time to music. In other words, it is possible to teach deaf children the muscular coordinations involved in the production of grouped, accented, and unaccented movements with some of the bodily members. Many schools for the deaf include "rhythm work" in their curricula with the assumption that such bodily movements carry over into speech and produce grouping, accentuation, and phrasing there. The validity of this assumption is somewhat questionable, however, since Hudgins and Numbers (6) in a recent unpublished study of the intelligibility of speech of 192 deaf subjects found that only 27% of 1150 sentences spoken by 115 profoundly deaf pupils were spoken rhythmically correct.

The problem of this paper is to determine whether

or not there are causes which might explain why deaf children find it more difficult to perform coordinations involved in the grouping of speech movements than when using other bodily movements. This study of the motor abilities of deaf children, as utilized in grouping, accentuating, and phrasing of movements with different bodily members including the speech organs, has been devised and carried out with a diagnostic purpose. If there are basic or structural causes involved, these should be discovered. If there are none, then why is it that the speech of deaf children is characterized by an absence of the normal English forms of grouping, accentuation, and phrasing in their speech?

## II. REVIEW OF LITERATURE

Squire, 1900, (11) found that normal hearing children, when required to read six lines of a syllable repeated six times per line, grouped those syllables into feet or unit-groups of accented and unaccented syllables. The smaller children were inclined to group them into trochee ( ˊ - ) and spondee ( ˊ ˊ ) feet. The older children grouped them into feet of three syllables with the accent on either the first (dactyl, ˊ - - ) or the last (anapaest, - - ˊ ) syllable. Squire also stated a definite correlation existed between the breathing movements and the groupings by each individual child.

Stetson, 1928, (12) stated that shifting the accent of words changes the vowels profoundly. The speed of syllable utterance changes the quality of the vowel with the change in accent. Movements of speech are shaped by rapid utterance; all phonetic coordinations shape themselves by and for maximum speed of utterance. Rhythm and accent make the phrase comprehensible; speed of utterance dominates this necessary rhythm and accent. Stetson further states that word accents are retained in the rhythmic grouping of phrases, and differences in the length of the syllables which constitute the

rhythm of speech are the most fundamental characteristics of the pronunciation of a language.

Griffith, 1929, (5) studying "Time Patterns in Prose" found that pauses were of three kinds: (1) those made for the purpose of distinct articulation and not felt as a pause by the reader or heard as a pause by the listener and those so felt and heard; (2) breath pauses during which the speaker is taking a breath; and (3) rest pauses during which vocal organs are at rest or falling into position of rest. The author defined sound units as those phonetic groups set off by pauses in the flow of speech. The sound unit, she further stated, is what establishes the phrase rhythm of a passage. Groupings within the sound unit are caused by pitch, stress, and tone color. The author also found that when progression within the sentence is from more rapid rate of utterance to slower, the final sound unit is usually a short one.

Hudgins, 1934, (7) compared the speech coordinations of 62 deaf and 25 normal subjects. He found that deaf speakers had slow and labored speech, that they prolonged vowels with a consequent distortion of these sounds, and that they had abnormalities of rhythm. He found further that there is a high correlation between the degree of hearing loss and the degree of speech

abnormality. Those subjects having the least hearing loss more nearly approximated the speech patterns of the normal. Those who were congenitally deaf acquired a certain type of abnormal speech coordination; those who acquired speech coordinations before the onset of deafness retained their normal coordinations even though they could no longer hear.

Hudgins and Numbers (8) in a recent, unpublished study of the speech of 192 deaf children classified three types of rhythm: sentences spoken with normal rhythm, those spoken with abnormal rhythm, and those spoken with a total absence of rhythm. These authors summarized their data with the statement that sentences spoken with correct rhythm by deaf pupils have an almost 2 to 1 advantage of being understood over those spoken with incorrect rhythm. The importance of speech rhythm for speech intelligibility, according to these authors, is indicated by the correlation of .56 between the two variables.

Blackburn, 1931,(3) studied the maximum rate of repeated movements of the diaphragm, tongue, jaw, and lips of thirteen normal speakers. Cross, 1936, (4) compared the voluntary movements of the hand, lips, jaws, tongue, and diaphragm of normal right handed speakers. Their findings were as follows:

| | Blackburn | Cross |
|---|---|---|
| | Movements per second | |
| Hand | ---- | 6.085 |
| Lips | 3.12 to 5.03 | 6.07 |
| Tongue | 2.61 to 7.31 | 5.17 |
| Jaws | 3.01 to 4.93 | 5.44 |
| Diaphragm | 2.88 to 5.64 | 5.13 |

Hudgins and Stetson, 1937, (9) studied the maximum rates of several articulatory organs of nine subjects and found that the tip of the tongue had the fastest rate (7.2 to 9.6 per second) with the other articulatory organs in this order: jaw, back of tongue, velum, and lips (5.7 to 7.7 per second). The total averages taken from the rates of the three unaccented syllables in a group of four in which the fourth syllable was accented, appear in the following table.

| | Movements per second |
|---|---|
| Lips | 6.7 |
| Tongue | 8.2 |
| Back of tongue | 7.1 |
| Jaws | 7.3 |
| Velum | 6.7 |

The higher rates of Hudgins and Stetson for the

articulatory organs as compared to those of Blackburn and Cross may be explained by the fact that Hudgins' and Stetson's rates were obtained by having the subjects use syllables containing consonants which involved the movements of the organ being tested rather than having them make "voluntary" movements.

Jenkins, 1941, (10) made a study of the maximum rate of repeated jaw movements with subjects ranging in age from seven years to maturity. He found that the rate of the movements of the jaw increased from the age of seven (3.67 for males) to seventeen (5.60 for males). Above that age there is little or no change in rate up to twenty years.

Voelker, 1938, (13) made a study of the comparative rate of utterance of deaf and normal speakers and found that the deaf subjects tended to speak almost 150 per cent slower than normal hearing people. More than 25 per cent of the deaf subjects spoke 80 or more words per minute. Over 15 per cent of the deaf subjects spoke 90 or more words per minute. The author concludes that 8.2 per cent of the deaf group who used more than 100 words per minute might well be considered normal without a doubt in regard to speech rate.

## III. EXPERIMENTAL METHODS

The experiment was arranged in three tests. In Test I the subjects utilized the movements of the hand, tongue, jaw, and breathing muscles in the production of unit-groups of one ( ↓ ), two ( ↓ - ) ( - ↓ ), and three ( ↓ - - ) ( - - ↓) beats. Test II substituted syllables tu, tus, stu, and stru for these movements. The grouping of Test I and II were paced by a light stimulus which recurred at 1 second intervals. Test III utilized the movements of the hand, tongue, jaw, and breathing muscles to execute the rhythm of the

- ↓ - ↓ - - ↓ - ↓

phrase "The stars are bright in the sky at night"; the substitution of syllables tu, tus, stu, and stru in the same rhythmic phrase followed; and finally meaningful words were substituted in the phrase pattern. The light stimulus was not used for the phrase.

### A. Methods and Procedure

The complete procedure took about an hour for each subject with short rest periods to prevent fatigue. The subjects sat in front of the recurring light stimulus and performed the required tests. They were instructed to group the movements or the syllables with the recurring light stimuli. The tasks were demonstrated,

and each subject was allowed to practice until the experimenter was sure the task was understood.

Test I consisted of prescribed groupings of movements of the hand, the jaw, the tongue, and the breathing muscles. The following procedure was followed in the case of each of these muscle groups. The subjects tapped with the preferred hand. The visual pattern for each prescribed group in terms of symbols was presented to the subjects, and each was given an opportunity to practice. The visual pattern was sometimes supplemented by tactile stimuli in order to make sure the prescribed group was understood. The rhythmic groups were presented in the following order: one beat per second ( ↓ ); two beats per second, trochee ( ↓ - ) and iamb ( - ↓ ); three beats per second, dactyl ( ↓ - - ) and anapaest ( - - ↓ ). The subjects were instructed to execute the prescribed groups during the 1 second intervals between light stimuli. Two to four lines were recorded for each individual unit-group. Each line contained 10 to 15 unit-groups. A sample of 25 to 50 repetitions of each individual unit-group were thus recorded for each subject.

Test II consisted of the same rhythm patterns with the syllables tu, tus, stu, and stru substituted for the tapping movements. The series using the syllable

tu was followed by series using tus, stu, and stru.

Test III employed the series of movements of Test I and the syllables of Test II in a prescribed phrase. The rhythm of the phrase "The stars are bright in the sky at night" was presented to the subjects without the words and tapped out by movements of hand, tongue, jaw, and breathing muscles; the syllables of Test II were repeated to this rhythmic phrase; finally, the meaningful words, "The stars are bright in the sky at night", were used in the phrase, and each subject was required to repeat it from five to ten times.

B. Apparatus

The pneumatic method of recording utilizing a motor-driven, variable-speed kymograph carrying a record 26 by 6 inches was used. The speed of the record was 4 to 6 cms. per second.

A light stimulus was provided by means of a Telechron motor with a frequency of 1 revolution per second which rotated a small mirror attached to its shaft. A light beam reflected from the rotating mirror passed downward across a ground glass screen 10 cms. in diameter. The moving light stimulus was visible for .12 seconds. The screen formed the front panel of a box containing the motor and lighting equipment. Copper

strips attached to the revolving axis of the motor completed an electric circuit and recorded the incidence of the light stimulus as it appeared at the top of the screen. Thus a record of the light stimuli was obtained simultaneously with the responses of the subjects.

Hand movements were recorded by a pneumatic device constructed by means of a soft rubber sponge covered with a rubber sack and connected by rubber tube to the kymograph recorder. Tapping of the hand on this device displaced a puff of air which in turn activated the stylus of the recorder. A kymogram of the hand movements consisted of a time line in .1 second intervals, the light stimulus in 1 second intervals, and the record of contacts of the hand as it tapped out the prescribed unit-groups.

Tongue movements were recorded by means of a light rubber capsule 2 cms. in diameter connected to the kymograph recorder by means of a rubber tube. The subject held the capsule against the aveolar ridge tapping it with the tip of his tongue. A kymogram of the tongue movements consisted of a time line in .1 second intervals, the light stimulus record in 1 second intervals, and the tracing of the tongue contacts with the capsule.

Jaw movements were recorded by means of a spiral

spring covered with thin rubber which formed a loop beneath the chin and was attached at either end to the temples of tortoise shell eye glass frames. The eye glass frames were in turn fastened securely behind the subject's head by means of a rubber band. A kymogram of the jaw movements consisted of a time line of .1 second intervals, the light stimulus recorded at 1 second intervals, and the tracing of jaw movements in terms of air pressure within the recorder.

Two tracings of movements of the breathing muscles were recorded simultaneously. The puff of breath produced by the muscles was recorded by means of a mask fitted over the subject's mouth. A second tracing was made by a pneumagraph encircling the subject at the upper abdominal level. A kymogram of the movements of the breathing muscles consisted of the time line in .1 second intervals, the light stimulus in 1 second intervals, a tracing of the puffs of breath, and a tracing of the pressure changes within the pneumagraph.

The syllable groupings were recorded with a combination of some of the previously described apparatus. Tracings of the jaw recorder, the pneumagraph, and the face mask were all used at one time. A kymogram for the syllables consisted of the time line in .1 second intervals, the light stimuli, the jaw movements and

the breathing movements as well as the tracings of the consonants and the vowels of the syllables.

C. Subjects

The subjects were eighteen deaf children, pupils of The Clarke School for the Deaf in Northampton, Massachusetts. They ranged in age from seven to nineteen years. Fourteen were boys, and four were girls. Five of the children were classified in Group B, partially deaf with auditory scores ranging from 226-425 out of a possible 800. (See Guilder and Hopkins, 1936, (6).) The remaining thirteen were classified as Group C, profoundly deaf, with auditory scores ranging from 0-225 out of a possible score of 800. The eighteen subjects were divided into the following two year age groups: 8-9 years, three subjects; 10-11 years, five subjects; 12-13 years, four subjects; 14-15 years, four subjects; and 18 and over, two subjects.

D. Analysis of Data

The duration of each correctly accented group was measured. Measurements could be made with accuracy up to a limit of .05 seconds. Average durations and measures of variability of individual unit-groups and phrases were obtained for the combined group of

subjects. Averages were also obtained for the separate age groups. Finally, averages for individual subjects were calculated.

## IV. RESULTS

The results will be presented in terms of average durations of the individual unit-groups. The data will be presented in the following order: Comparisons of the average durations of the individual unit-groups performed by the several bodily members; the average duration of the syllable tu will be compared with these; the average durations of the syllable groups composed of tu, tus, stu, and stru will be presented; the average durations of the phrase movements will be presented and compared; and finally, data of the separate age groups and individual subjects in all three tests will be presented and compared.

### A. Results of Test I

Table I shows average durations of the entire group of subjects for the unit-groups performed by the hand, tongue, jaw, and breathing muscles. The averages for the durations of the syllable tu are included for purposes of comparison.

Subjects of all ages were able to perform the prescribed tasks of grouping movements with the hand, tongue, jaw, and breathing muscles in groups of 2 and 3 beats within 1 second intervals. The averages for

the entire group of subjects ranged as follows: hand tapping, .44 (trochee) to .73 seconds (anapaest); tongue tapping, .57 (trochee) to .78 seconds, (anapaest); jaw tapping, .69 (iamb) to .89 seconds (dactyl); breathing muscles, .70 (iamb) to .83 seconds (dactyl).

The data in Table I shows further the relative facility of the several bodily members in executing the prescribed groupings. The average durations of the unit-groups performed by hand are the shortest; the tongue movements are next in order; and the jaw and breathing movements, which are practically identical in length, require the greater time. The differences between the average durations of the unit-groups performed by the hand and tongue, and the tongue and jaw are statistically significant.

The hand is apparently more adept at the task of producing a series of movements which are grouped according to a prescribed rhythmic pattern and paced by recurring stimuli at regular intervals. It is of interest to note, however, that the speech organs, acting separately, are likewise perfectly able to perform similar tasks and to keep "in step" with the light stimuli. Thus it appears clearly demonstrated by this portion of Test I that the deaf subjects are capable of producing rhythmic patterns with the movements of the individual

speech organs.

When the individual speech organs are called upon to act in unison in the production of similar rhythmic patterns substituting simple syllables for the previous abstract movements, however, the task appears more difficult.

The average durations for the unit-groups containing the syllable tu, as contrasted with those containing the individual movements of the tongue, jaw, and breathing muscles, show a distinct increase. The average durations for the two-syllable groups, trochee and iamb, containing the syllable tu, are .85 and .83 seconds respectively (Table I). When a third syllable is added to the group forming dactyls or anapaests, the average durations are .95 and .97 seconds respectively. An average duration greater than .90-.94 seconds is an indication that the subjects are not able to manage the grouping within the allotted 1 second intervals. The pauses between groups occupy not less than .07 seconds, and pauses for breath require more time.

As noted above, however, these same pupils are able to group simple "tapping" movements of the individual speech organs within the allotted 1 second intervals. The "tapping" movement of the tongue used in this test is almost identical with the movement

required of the tongue in the articulation of t and the vowel in the neutral u. The jaw movements and the action of the breathing muscles are likewise identical. It is apparent, therefore, that the mere substitution of the syllable tu for the tapping movements of the tongue, jaw, and breathing muscles does not necessarily impose an impossible task from the point of view of the individual organs. This substitution does, however, complicate the task from the point of view of motor coordination. Further evidence of the fact is found in the combined average of the durations of the unit-groups executed by the tongue, jaw, and breathing muscles. This combined average ranges from .67 (trochee, iamb) to .82 seconds (dactyl). Similar averages for the syllable tu range from .83 (iamb) to .97 seconds (anapaest). (See Table I.)

To summarise Test I: The data show that the hand executed the prescribed unit-group movements within the 1 second intervals with the greatest facility. Separately, the tongue, the jaw, and the breathing muscles executed the same prescribed tasks well within the 1 second interval. The substitution of the syllable tu for these same prescribed tasks, however, shows an increased duration out of all proportion to the task imposed. Finally, the combined average of the durations

of the unit-groups executed by the tongue, jaw, and breathing muscles show that the longest unit-group duration (dactyl, .82 seconds) is slightly shorter than the shortest unit-group duration (iamb, .83 seconds) for the syllable tu.

B. Results of Test II

The substitution of the simple syllable tu for the prescribed movements executed by the tongue, jaw, and breathing muscles meant that these individual speech organs were now being combined as a functional unit in the production of speech. The data presented in Test I showed that the syllable tu slowed down the process of grouping to a considerable degree. In order to study further the effect of grouping syllables instead of simple movements of the speech organs, Test II was devised. Only syllables containing consonants using the tip of the tongue in their articulation were used, and the same neutral vowel u was kept in each of the syllables. The syllables were chosen in what was apparently an order of increasing complexity by reason of the combination of consonants used. The syllables tu, tus, stu, and stru were chosen, and each in turn were grouped in the four types of unit-groups.

When the syllables tu, tus, stu, and stru were

substituted for the movements in unit-groups, trochee, iamb, dactyl, and anapaest, there was a decided increase in the group durations (Table II). Furthermore, as the complexity of the syllable is increased by the addition of consonants, the durations are proportionately increased.

The averages for the entire group of subjects ranged as follows: tu, .83 (iamb) to .97 seconds (anapaest); tus, .86 (iamb) to 1.04 seconds (anapaest); stu, .89 (iamb) to 1.04 seconds (anapaest); and stru, .86 (iamb) to 1.04 seconds (dactyl). The deaf subjects were able to group each of the syllables, therefore, in the two-syllable unit groups (trochee and iamb) within the 1 second interval without much difficulty. They were not able, however, to manage within the 1 second intervals, the three-syllable unit-groups containing any of the syllables tus, stu, or stru. (See Table II.) The differences between the average durations of the unit-groups containing tu and tus, tu and stu, tu and stru are statistically significant. The average durations of groups containing tus, stu, and stru were not significantly different.

To summarize Test II: The addition of consonants to the simple syllable tu caused a significant increase

in the unit-group durations.

C. Results of Test III

The data of Test III closely parallel those of Test I and II. Test III utilized the series of movements of Test I and the syllables of Test II in a larger rhythmic unity, the phrase. The phrase pattern used was the nine syllable phrase "The stars are bright in the sky at night". The subjects were first instructed to reproduce the indicated rhythm with the movements and syllables substituted for the words and without the recurring light stimuli. In the analysis of the data, comparisons will be made between the combined average durations of the movements of the tongue, jaw, and breathing muscles and the average durations containing the syllable tu. Next comparisons will be made between the average durations of the relatively simple syllable tu and the more complicated syllables tus, stu, and stru. Finally affects of the substitution of the meaningful words in the phrase will be shown.

As in Test I, the subjects were able to perform the prescribed rhythm of the phrase with the hand movements in a shorter time than with any of the articulatory members. (See Table III.) The movements of the breathing muscles were next in order; the phrasing of

the movements of the tongue required more time than that of the breathing muscles; phrasing of the jaw movements required the longest time of the entire group. The differences are not large between the average durations of the phrasing movements of the hand, tongue, jaw, and breathing muscles. The averages range from 3.21 (hand) to 3.37 seconds (jaw), a difference of .16 seconds. This difference, however, is statistically significant, while the difference between the averages of the tongue and jaw movements is not significant. The combined average duration of the phrase performed by the tongue, jaw, and breathing muscles is 3.33 seconds (Table III). When, however, the simple syllable tu is substituted for the separate movements of the speech organs, these articulatory members acting in unison to produce the syllable tu cause a significant increase, .33 seconds, in the phrase duration.

As noted previously in Test I, the addition of consonants to the simple syllable tu causes a proportionate increase in the duration of the phrase as the complexity of the syllable is increased (Table III). The average durations of the phrases containing the syllables range from 3.66, tu, to 4.42 seconds, stru. The differences between the phrase durations containing

tu and tus, tu and stu, tu and stru proved statistically significant. But the phrase durations containing tus, stu, and stru were not found significantly different.

When the meaningful words, "The stars are bright in the sky at night", were substituted in the same phrase pattern, there is an additional increase in phrase durations. The average phrase duration containing the "meaningful" words was 4.46 seconds, an increase of .8 and 1.13 seconds over that containing the simple syllable tu and over that of the combined average, respectively (Table III). The "meaningful" words although they are all words familiar to the subjects add still further to the task of articulation since, in addition to the front linguals used in the nonsense syllables, the subjects must make transitions from these to labial and back lingual consonants contained in the phrase. This probably accounts for the additional retardation observed in repeating the phrase.

To summarise Test III: The hand performs the prescribed movements of the phrase with the most facility. Again, the tongue, the jaw, and the breathing muscles, functioning independently, performed the prescribed phrasing movements in much less time than when they were combined in the production of the syllable tu.

More complicated syllables retard the subjects still further. The use of the meaningful words prolongs the phrase durations even more.

D. Analysis of the Data According to Age

The age group data show a tendency for the unit-group durations to decrease in proportion to the age increase (Table IV). The durations of the two-syllable unit-groups do not show as great a decrease between the age groups as those of the three-syllable unit-group.

The subjects at all age levels were able to perform the prescribed unit-groups within the 1 second intervals with the hand, the jaw, the tongue, and the breathing muscles with the exception of the 8-9 year group (breathing muscles, anapaest, 1.04 seconds). (See Table IV.)

Further evidence of the ability of the deaf subjects to perform the tasks with the individual bodily members is found in the combined averages of the unit-group durations (Table IV). Each age group has a combined average well within the 1 second intervals, and the averages decrease with age. The ranges for the combined averages are: trochee, .72 (8-9 years) to .63 seconds (14-15 years); iamb, .74 (8-9 years) to .60 seconds (18 years); dactyl, .92 (8-9 years) to .72

seconds (12-13 years); and anapaest, .91 (8-9 years) to .74 seconds (18 years).

The substitution of the simple syllable tu for the movements of the tongue, jaw, and breathing muscles increases the durations of the unit-group in each age group (Table IV). The 8-9 year group were not able to group the syllable in the 1 second intervals in the three-syllable unit-groups (dactyl, 1.07 seconds; anapaest, 1.06 seconds). The 10-11 year group could not group the syllable in the anapaest form (1.01 seconds). The decreases from the youngest to the oldest age group in the unit-group durations containing the syllables were greater than those for the combined averages as previously noted.

The addition of the consonants to the simple syllable tu made a greater increase in the unit-group durations for tus, stu, and stru in the 8-9 year group than for any other age group (Table V).

The Test III data arranged according to age show that all phrase durations decrease uniformly from youngest to oldest age group (Table VI). It is particularly interesting to note that the average phrase durations for the movements of the breathing muscles were closer to the average durations containing the syllable tu in each age group than for any similar

comparison of the unit-groups. In other words, when the deaf subjects were asked to join several of the unit-groups into a phrase or breath group, the prescribed task of grouping the movements of the breathing muscles in a rhythmic phrase offered almost as great a task as the motor coordination necessary for the production of the syllable tu (Table VI). In Table VI, the combined average durations of the phrasing movements of the tongue, jaw, and breathing muscles are less than those of the phrases containing the syllable tu. This is true for subjects of each age group with the exception of the 14-15 year group.

The average phrase durations containing the meaningful words increase more in the 10-11 and 12-13 year groups than the others (Table VI).

To summarize the age group data: The 8-9 year age group required the longest time for both the unit-groups and the phrase. There was a tendency for the phrase durations to decrease at each successive age level. The combined average of the unit-groups and the phrases performed by the individual speech organs were shorter than those containing the simple syllable tu. The age group data showed performances of prescribed tasks were influenced slightly by age.

E. Averages of Individual Subjects

The average durations for individual subjects show that all subjects can perform the prescribed tasks in the two-beat unit-groups (trochee and iamb) with the hand, tongue, jaw, and breathing muscles within the 1 second intervals. With a few exceptions, these tasks can also be performed in the three-beat unit-groups (dactyl and anapaest) within the 1 second intervals. (See Tables VII, VIII, IX, and X .)

The combined durations of the movements of the tongue, jaw, and breathing muscles of each subject in the trochee are less than those in which the syllable tu was substituted (Table VII). The differences ranged from .05 to .37 seconds. In the iamb unit-group there is one exception to this; the differences range from 0 to .31 seconds (Table VIII). In the dactyl unit-group, there is also one exception; the differences range from .01 to .23 seconds (Table IX). In the anapaest unit-group there is one exception; the differences range from .01 to .22 seconds (Table X).

The phrase durations for all subjects showed the same tendency for the combined average durations to be shorter than the phrase durations containing the syllable tu (Table XI). The phrase durations contain-

ing syllables tus, stu, and stru showed more increase with the younger subjects. The use of the meaningful words in the same rhythmic pattern also taxed the younger subjects more than the older ones (Table XI).

To summarize the individual data: The individual averages further pointed to the evidence that the tongue, jaw, and breathing muscles can perform prescribed tasks in unit-groups and phrases in a shorter time when performing separately than when utilized together in the production of the syllable tu. The individual subjects' durations containing the syllables tus, stu, and stru were, generally speaking, lengthened as the complexity increased.

## V. DISCUSSION OF RESULTS

Deaf children have difficulty in grouping, accenting, and phrasing syllables. Grouping, accentuation, and phrasing are the basic aspects of speech rhythm and play an important role in the intelligibility of speech. In the flow of normal speech, consonants and vowels have no stereotyped durational, qualitative, or intensity values. Syllables carry rhythm of speech; they are accented or unaccented, long or short, depending upon the demands of the rhythmic groups of which they are a part (Stetson 12, pp. 207-208). Consonants and vowels are, therefore, long or short, strong or weak, depending upon the strength and duration of the syllables in which these elements appear.

The results of this study showed that deaf children have no difficulty in grouping, accenting, and phrasing a series of movements of the individual speech organs acting separately and entirely divorced from speech. But speech is produced by the integrated action of a number of individual organs including the tongue, the jaw, and the breathing muscles working in unison. Deaf children apparently have difficulty in integrating the several parts of the speech mechanism with the consequent slowing down of the entire speech

process. Breathing muscles which were capable of grouping puffs of breath into rhythmic units failed when syllables were substituted. The tongue and the jaw which tapped out unit-group and phrase rhythms smoothly and rapidly were slowed down when these same movements were required to produce consonants and simple vowels.

Why is it so difficult for deaf children to manage the tasks of accentuation and grouping when syllables and words are substituted for the movements of individual speech organs? The production of rhythm does not depend upon hearing the sounds, because all the subjects tested in this study could perform prescribed rhythmic tasks with the tongue, jaw, and breathing muscles without any sound stimuli. Even speech rhythm is not dependent upon hearing since subjects who have lost their hearing after having acquired speech retain normal speech rhythm (Hudgins, 7 , Page 44).

The habits that deaf children acquire in their early speech development probably interfere with the ability of the children to develop speech rhythm. At the beginning of speech development, deaf children are taught individual speech sounds. Syllables are broken up into separate consonants and vowels. These sounds are taught entirely apart from syllables or words. By reason of an insistence upon "accuracy of elements",

each sound is learned with the same quantitative and qualitative value. Finally, when deaf children are required to combine those separate sounds to form syllables or words, each sound retains its original quantitative and qualitative value. This inflexibility as to quantity and quality of elements prevents accentuation and phrasing, because accented syllables receive greater stress and greater duration than unaccented syllables. Consonants and vowels, therefore, which occur in accented and unaccented syllables must be long or short, strong or weak, as the rhythmic pattern demands.

To illustrate, the addition of final s to tu, making tus, means another definite additional consonant duration for the deaf children. When deaf children repeat tus in anapaest rhythm ( - - ⊥ ), for instance, the unit group is given as "tusss, tusss, TUSSS". The addition of the final s to each syllable increases considerably the durational value of the unit-group. For normal speakers, the repetition of tus in the same unit-group becomes "tu stu STUS". The addition of the s adds length only to the final syllable. When deaf children repeat stu in an anapaest unit-group, it often becomes "ssstu, ssstu, SSSTU". They are inclined to separate the compound consonant into its component parts and

to give each part as a distinct consonant. Compound consonants are, normally, fusions of two or three consonant strokes which serve as a single consonant and requires little more time than single consonants. (See Stetson, 12, Pp. 119-121.)

Special rhythm classes for deaf children attempt to set into a rhythm consonants and vowels which have definite quantitative and qualitative values as a result of speech habits previously formed. The age group data of this study show that such attempts make a slight improvement in the speech of deaf children, since the older of the eighteen subjects showed a greater ability in grouping, accenting, and phrasing syllables than the younger ones. But even the adult deaf subjects never reach the mastery in grouping, accenting, and phrasing of 8 to 10 year old normal children. (See Bertolio, 2, Page 36.)

## VI. SUMMARY

This study was devised for the purpose of making comparisons of the relative facilities with which deaf children perform tasks involving the grouping, accentuation, and phrasing of a series of movements with hand, tongue, jaw, breathing muscles, and finally with the speech mechanism as a unit.

The pneumatic method of recording utilizing a kymograph was used. Suitable apparatus was used to obtain the air pressure changes as the various members and the breathing muscles performed the prescribed tasks.

Three rhythmic-motor tests were devised. Test I compared the abilities of the deaf subjects to perform grouping, accentuation, and phrasing with the hand, tongue, jaw, and breathing muscles. The syllable tu was substituted to compare those separate movements with the same members acting in unison to produce a syllable.

In Test II, the syllables tus, stu, and stru were substituted for the movements of the individual organs.

Test III was a test of phrasing, using individual speech organs, syllables, and finally words.

Results of Test I showed that (1) the deaf subjects were able to move the hand to execute the prescribed

tasks in all unit-groups with the greatest facility; the tongue, next; and the jaw and the breathing muscles with almost identical facility. (2) The tongue, the jaw, and the breathing muscles performing the prescribed tasks separately could easily accomplish the task within the 1 second intervals. (3) The substitution of the simple syllable tu in the same rhythmic unit-group caused an increase in duration. (4) The combined average durations for the movements of the tongue, jaw, and breathing muscles were shorter in each unit-group than the durations containing the syllable tu.

The results of Test II showed that (1) the addition of more consonants to the simple syllable tu caused greater length in unit-group durations in proportion to their complexity.

The results of Test III showed that (1) phrase durations were similar in results to unit-group durations. The separate movements of the tongue, jaw, and breathing muscles were performed faster in the prescribed phrase rhythm than when the syllable tu was substituted. (2) The addition of consonants increased the phrase durations containing tus, stu, and stru. (3) The use of the meaningful words, "The stars are bright in the sky at night", increased the phrase duration still further.

The data of the experiment show that physiologically there is no reason why deaf children cannot produce speech with normal English forms of grouping, accentuation, and phrasing. Yet the 18 subjects used in this study showed a definite retardation when required to group syllables into single unit-groups and phrases.

Hearing is an important factor in learning rhythms, but deaf children learn to group, accent and phrase various types of movements. It is suggested that habits acquired during early speech development interfere with the development of speech rhythm.

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TABLE I

Average Durations in Seconds for Trochee, Iamb, Dactyl, and Anapaest Unit-Groups Using Movements of Hand, Tongue, Jaw, and Breathing Muscles and Containing Syllable Tu, For Entire Group of Subjects.

| | No. | $\bar{M}_1$ | $\sigma_d$ | Dif. | C.R. | No. | $\bar{M}_1$ | $\sigma_d$ | Dif. | C.R. |
|---|---|---|---|---|---|---|---|---|---|---|
| Hand | 402 | .44 | | | | 481 | .56 | | | |
| | | | .01 | .13 | 13. | | | .01 | .07 | 7. |
| Tongue | 440 | .57 | | | | 300 | .63 | | | |
| | | | .01 | .15 | 15. | | | .01 | .06 | 6. |
| Jaw | 363 | .72 | | | | 313 | .69 | | | |
| | | | .01 | .01 | 1.00 | | | .01 | .01 | 1. |
| Breath. Muscles | 312 | .71 | | | | 256 | .70 | | | |
| Av. of T, J, & Breath. Muscles | 1115 | .67 | - | .18 | - | 869 | .67 | - | .16 | - |
| Tu | 343 | .85 | | | | 316 | .83 | | | |

| | No. | $\bar{M}_1$ | $\sigma_d$ | Dif. | C.R. | No. | $\bar{M}_1$ | $\sigma_d$ | Dif. | C.R. |
|---|---|---|---|---|---|---|---|---|---|---|
| Hand | 377 | .67 | | | | 372 | .73 | | | |
| | | | .01 | .08 | 8. | | | .01 | .05 | 5. |
| Tongue | 263 | .75 | | | | 262 | .78 | | | |
| | | | .01 | .14 | 14. | | | .01 | .04 | 4.00 |
| Jaw | 278 | .89 | | | | 296 | .82 | | | |
| | | | .01 | .06 | 6. | | | - | - | |
| Breath. Muscles | 295 | .83 | | | | 241 | .82 | | | |
| Av. of T,J, & Breath. Muscles | 836 | .82 | - | .13 | - | 799 | .81 | - | .16 | - |
| Tu | 262 | .95 | | | | 246 | .97 | | | |

TABLE II

Average Durations in Seconds for Trochee, Iamb, Dactyl, and Anapaest Unit-Groups Containing Syllables For Entire Group of Subjects.

| | ˘ – | | | | | – ˘ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | M | σd | Dif. | C.R. | No. | M | σd | Dif. | C.R. |
| Tu | 343 | .85 | | | | 316 | .83 | | | |
| | | | .01 | .04 | 4. | | | .01 | .03 | 3. |
| Tus | 234 | .89 | | | | 244 | .86 | | | |
| | | | .01 | .01 | 1. | | | .01 | .03 | 3.00 |
| Stu | 211 | .90 | | | | 186 | .89 | | | |
| | | | .01 | .02 | 2.00 | | | .01 | .03 | 3.00 |
| Stru | 170 | .88 | | | | 191 | .86 | | | |

| | ˘ – – | | | | | – – ˘ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | M | σd | Dif. | C.R. | No. | M | σd | Dif. | C.R. |
| Tu | 262 | .95 | | | | 246 | .97 | | | |
| | | | .02 | .07 | 3.5 | | | .01 | .07 | 7.00 |
| Tus | 204 | 1.02 | | | | 193 | 1.04 | | | |
| | | | .01 | .02 | 2.00 | | | - | - | - |
| Stu | 209 | 1.00 | | | | 176 | 1.04 | | | |
| | | | .02 | .04 | 2. | | | .02 | .05 | 2.5 |
| Stru | 140 | 1.04 | | | | 156 | .99 | | | |

TABLE III

Average Durations in Seconds of the Phrase for Entire Group of Subjects When the Tapping Movements of the Several Bodily Members and the Syllables Tu, Tus, Stu, and Stru are Substituted for the Original Words.

\- 1 - 1 - - 1 - 1

| | No. | M | σd | Dif. | C.R. |
|---|---|---|---|---|---|
| Hand | 143 | 3.21 | | | |
| | | | .02 | .12 | 6. |
| Tongue | 133 | 3.33 | | | |
| | | | .02 | .04 | 2. |
| Jaw | 114 | 3.37 | | | |
| | | | .02 | .07 | 3.5 |
| Breath. Musc. | 89 | 3.30 | | | |
| Aver. of T, J, & Breath. Muscles | 336 | 3.33 | - | - | - |
| | | | - | .33 | - |
| Tu | 77 | 3.66 | | | |

\- 1 - 1 - - 1 - 1

| | No. | M | σd | Dif. | C.R. |
|---|---|---|---|---|---|
| Tu | 77 | 3.66 | | | |
| | | | .03 | .46 | 15.3 |
| Tus | 65 | 4.12 | | | |
| | | | .38 | .06 | .16 |
| Stu | 68 | 4.18 | | | |
| | | | .39 | .24 | .61 |
| Stru | 80 | 4.42 | | | |
| | | | - | .04 | - |
| *Words | 92 | 4.46 | | | |

* The stars are bright in the sky at night.

TABLE IV

Average Durations in Seconds for Trochee, Iamb, Dactyl, and Anapaest Unit-Groups Using Movements of Hand, Tongue, Jaw, and Breathing Muscles and Containing Syllable Tu for Age Groups.

| | ⏑ – | | – ⏑ | | ⏑ – – | | – – ⏑ | |
|---|---|---|---|---|---|---|---|---|
| | M | $\sigma_m$ | M | $\sigma_m$ | M | $\sigma_m$ | M | $\sigma_m$ |
| Hand: 8-9 | .40 | .01 | .56 | .01 | .77 | .03 | .78 | .03 |
| 10-11 | .43 | .01 | .63 | .01 | .71 | .01 | .74 | .01 |
| 12-13 | .49 | .01 | .50 | .02 | .69 | .01 | .69 | .01 |
| 14-15 | .38 | .01 | .52 | .01 | .57 | .01 | .71 | .01 |
| 18# | .52 | .02 | .55 | .01 | .54 | .01 | .71 | .01 |
| Tongue: | | | | | | | | |
| 8-9 | .61 | .01 | .68 | .02 | .87 | .03 | .84 | .03 |
| 10-11 | .62 | .01 | .67 | .01 | .82 | .01 | .84 | .01 |
| 12-13 | .56 | .01 | .59 | .01 | .71 | .01 | .73 | .01 |
| 14-15 | .50 | .01 | .58 | .02 | .65 | .10 | .73 | .02 |
| 18# | .49 | .01 | .54 | .01 | .67 | .02 | .78 | .01 |
| Jaw: 8-9 | .74 | .02 | .69 | .02 | .92 | .02 | .85 | .02 |
| 10-11 | .72 | .01 | .76 | .02 | .98 | .01 | .90 | .02 |
| 12-13 | .70 | .01 | .63 | .02 | .76 | .01 | .76 | .02 |
| 14-15 | .75 | .02 | .66 | .02 | .78 | .02 | .81 | .01 |
| 18# | .71 | .02 | .56 | .02 | .84 | .01 | .71 | .02 |
| Breath. Musc.: 8-9 | .80 | .02 | .85 | .02 | .96 | .02 | 1.04 | .03 |
| 10-11 | .68 | .01 | .75 | .01 | .94 | .02 | .87 | .02 |
| 12-13 | .64 | .02 | .66 | .02 | .80 | .02 | .76 | .02 |
| 14-15 | .65 | .01 | .58 | .01 | .76 | .01 | .75 | .01 |
| 18# | .74 | .02 | .69 | .01 | .74 | .02 | .74 | .02 |
| Av. of T, J, & Br. Musc.: | | | | | | | | |
| 8-9 | .72 | | .74 | | .92 | | .91 | |
| 10-11 | .67 | | .73 | | .91 | | .90 | |
| 12-13 | .63 | | .63 | | .72 | | .74 | |
| 14-15 | .63 | | .61 | | .73 | | .76 | |
| 18# | .65 | | .60 | | .75 | | .74 | |
| Tu: 8-9 | .88 | .02 | .77 | .01 | 1.07 | .02 | 1.06 | .01 |
| 10-11 | .83 | .01 | .84 | .01 | .91 | .01 | 1.01 | .02 |
| 12-13 | .82 | .02 | .86 | .02 | .81 | .01 | .90 | .01 |
| 14-15 | .81 | .01 | .80 | .01 | .87 | .01 | .91 | .01 |
| 18# | .87 | .01 | .71 | .02 | .84 | .02 | .84 | .02 |

TABLE V

Average Durations in Seconds for Trochee, Iamb, Dactyl, and Anapaest Unit-Groups Containing Syllables for Age Groups.

| | ˊ - | | - ˊ | | ˊ - - | | - - ˊ | |
|---|---|---|---|---|---|---|---|---|
| | M | $\sigma_m$ | M | $\sigma_m$ | M | $\sigma_m$ | M | $\sigma_m$ |
| **Tu:** | | | | | | | | |
| 8-9 | .88 | .02 | .77 | .01 | 1.07 | .02 | 1.06 | .01 |
| 10-11 | .83 | .01 | .84 | .01 | .91 | .01 | 1.01 | .02 |
| 12-13 | .82 | .02 | .86 | .02 | .81 | .01 | .90 | .01 |
| 14-15 | .81 | .01 | .80 | .01 | .87 | .01 | .91 | .01 |
| 18# | .87 | .01 | .71 | .02 | .84 | .02 | .84 | .02 |
| **Tus:** | | | | | | | | |
| 8-9 | .90 | .02 | .81 | .02 | 1.16 | .02 | 1.24 | .03 |
| 10-11 | .88 | .02 | .86 | .01 | .98 | .02 | .95 | .02 |
| 12-13 | .88 | .02 | .86 | .02 | 1.03 | .03 | .98 | .03 |
| 14-15 | .86 | .01 | .84 | .02 | 1.01 | .02 | 1.06 | .02 |
| 18# | .80 | .01 | .90 | .02 | .93 | .004 | .89 | .01 |
| **Stu:** | | | | | | | | |
| 8-9 | .91 | .02 | .90 | .01 | 1.19 | .02 | 1.16 | .03 |
| 10-11 | .87 | .02 | .85 | .02 | .92 | .09 | .91 | .02 |
| 12-13 | .88 | .02 | .93 | .01 | 1.02 | .03 | 1.16 | .02 |
| 14-15 | .92 | .02 | .81 | .02 | 1.01 | .01 | 1.03 | .02 |
| 18# | .83 | .02 | .81 | .02 | .91 | .02 | .92 | .01 |
| **Stru:** | | | | | | | | |
| 8-9 | .98 | .01 | .97 | .01 | 1.42 | .01 | 1.38 | .01 |
| 10-11 | .88 | .02 | .82 | .01 | .97 | .04 | .91 | .05 |
| 12-13 | .86 | .02 | .81 | .02 | .98 | .02 | 1.01 | .03 |
| 14-15 | .83 | .01 | .81 | .01 | 1.04 | .02 | .93 | .01 |
| 18# | .87 | .02 | .86 | .01 | .93 | .01 | .89 | .02 |

TABLE VI

Average Durations in Seconds of the Phrase When the Tapping Movements of the Several Bodily Members and the Syllables Tu, Tus, Stu, Stru Are Substituted for Original Words for Age Groups.

- ı - ı - - ı - ı

| | M | $\sigma_m$ | | M | $\sigma_m$ |
|---|---|---|---|---|---|
| Hand: | | | Tu: | | |
| 8-9 | 3.74 | .08 | 8-9 | 3.89 | .06 |
| 10-11 | 3.19 | .07 | 10-11 | 3.87 | .08 |
| 12-13 | 3.10 | .05 | 12-13 | 3.78 | .08 |
| 14-15 | 3.02 | .06 | 14-15 | 3.06 | .07 |
| 18# | 2.65 | .09 | 18# | 3.28 | .12 |
| Tongue: | | | | | |
| 8-9 | 3.63 | .10 | 8-9 | 4.72 | .06 |
| 10-11 | 3.71 | .06 | 10-11 | 4.61 | .12 |
| 12-13 | 3.09 | .05 | 12-13 | 3.77 | .11 |
| 14-15 | 3.12 | .09 | 14-15 | 3.63 | .10 |
| 18# | 2.41 | .07 | 18# | 3.30 | .04 |
| Jaw: | | | Stu: | | |
| 8-9 | 3.28 | .09 | 8-9 | 4.60 | .08 |
| 10-11 | 3.24 | .05 | 10-11 | 4.47 | .10 |
| 12-13 | 3.25 | .13 | 12-13 | 4.20 | .22 |
| 14-15 | 3.23 | .10 | 14-15 | 3.45 | .10 |
| 18# | 3.23 | .07 | 18# | 3.62 | .11 |
| Breath. Musc. | | | Stru: | | |
| 8-9 | 3.88 | .19 | 8-9 | 5.70 | .10 |
| 10-11 | 4.17 | .06 | 10-11 | 4.59 | .08 |
| 12-13 | 3.08 | .08 | 12-13 | 4.51 | .16 |
| 14-15 | 3.07 | .14 | 14-15 | 3.57 | .10 |
| 18# | 2.67 | .08 | 18# | 3.73 | .07 |
| Av. of T, J, & Br. Musc. | | | *Words: | | |
| 8-9 | 3.62 | | 8-9 | 5.43 | .16 |
| 10-11 | 3.71 | | 10-11 | 4.87 | .18 |
| 12-13 | 3.14 | | 12-13 | 4.61 | .06 |
| 14-15 | 3.14 | | 14-15 | 3.60 | .10 |
| 18# | 2.77 | | 18# | 3.50 | .09 |

*The stars are bright in the sky at night.

TABLE VII

Average Durations in Seconds for Trochee Unit-Groups Using Movements of Hand, Tongue, Jaw, and Breathing Muscles and Containing Syllables for Individual Subjects

Trochee 1 -

| | H | T | J | Br. Mu. | Ave. T,J,& Br. Musc. | Tu | Tus | Stu | Stru |
|---|---|---|---|---|---|---|---|---|---|
| 8-9 | | | | | | | | | |
| *Jack, D. | .53 | .51 | .54 | .63 | .55 | .75 | .86 | .82 | -- |
| Casteline, B. | .35 | .64 | .81 | .97 | .69 | .95 | .86 | .97 | .97 |
| *Monahan, K. | .42 | .67 | .79 | .86 | .69 | .78 | .92 | .88 | -- |
| Age Group Ave. | .40 | .61 | .74 | .80 | .72 | .88 | .90 | .91 | .98 |
| $\sigma_m$ | | .01 | .02 | .02 | | .02 | .02 | .02 | .01 |
| 10-11 | | | | | | | | | |
| *Desrosier, T. | .57 | .74 | .58 | .68 | .67 | .97 | .99 | 1.05 | -- |
| Cockburn, A. | .41 | .71 | .64 | .70 | .68 | .85 | .68 | .93 | .94 |
| *Clark, H. | .33 | .45 | .72 | .72 | .63 | .71 | .78 | .78 | -- |
| Ying, M. | .52 | .73 | .84 | .74 | .77 | .92 | 1.03 | 1.01 | -- |
| Casella, A. | .43 | .53 | .80 | .59 | .64 | .83 | .87 | .84 | .80 |
| Age Group Ave. | .43 | .62 | .72 | .68 | .67 | .83 | .88 | .87 | .88 |
| $\sigma_m$ | | .01 | .01 | .01 | | .01 | .02 | .02 | .02 |
| 12-13 | | | | | | | | | |
| Briggs, J. | .49 | .36 | .63 | .68 | .56 | .92 | .87 | .82 | .94 |
| *Tucker, E. | .46 | .67 | .67 | .71 | .68 | .86 | .86 | .89 | .90 |
| Domingue, M. | .50 | .62 | .84 | .85 | .77 | 1.10 | 1.14 | 1.06 | -- |
| *Cummings, S. | .54 | .58 | .69 | .42 | .56 | .64 | .79 | .76 | .82 |
| Age Group Ave. | .49 | .56 | .70 | .64 | .63 | .82 | .88 | .88 | .86 |
| $\sigma_m$ | | .01 | .01 | .02 | | .02 | .02 | .02 | .02 |
| 14-15 | | | | | | | | | |
| Berry, P. | .42 | .54 | .85 | .55 | .65 | .83 | .97 | .92 | .90 |
| Hall, E. | .33 | .45 | .77 | .71 | .64 | .82 | .95 | .98 | -- |
| Wing, M. | .42 | .68 | .52 | .67 | .62 | .91 | .78 | .93 | .82 |
| Ovitt, E. | .42 | .44 | .44 | .72 | .53 | .83 | .97 | .92 | .90 |
| Age Group Ave. | .38 | .50 | .75 | .65 | .63 | .81 | .86 | .92 | .83 |
| $\sigma_m$ | | .01 | .02 | .01 | | .01 | .01 | .02 | .01 |
| 18# | | | | | | | | | |
| Blundell, C. | .50 | .50 | .66 | .81 | .66 | .90 | .82 | .83 | .83 |
| Miller, V. | .49 | .51 | .77 | .69 | .66 | .87 | .84 | .86 | .89 |
| Age Group Ave. | .52 | .49 | .71 | .74 | .65 | .87 | .80 | .83 | .87 |
| $\sigma_m$ | | .01 | .02 | .02 | | .01 | .01 | .02 | .02 |
| General Average | .44 | .57 | .72 | .71 | .67 | .85 | .89 | .90 | .88 |

*Classified as partially deaf (Group B)

TABLE VIII

Average Durations in Seconds for Iamb Unit-Groups Using Movements of Hand, Tongue, Jaw, and Breathing Muscles and Containing Syllables for Individual Subjects.

Iamb - 1

| | H | T | J | Br. Mu. | Ave. T,J,& Br. Musc. | Tu. | Tus | Stu | Stru |
|---|---|---|---|---|---|---|---|---|---|
| 8-9 | | | | | | | | | |
| *Jack, D. | .63 | .45 | .54 | .62 | .54 | .68 | .69 | .90 | -- |
| Casteline, B. | .48 | .64 | .81 | .97 | .81 | .95 | .86 | .97 | .97 |
| *Monahan, K. | .58 | .67 | .86 | .80 | .78 | .85 | .92 | .99 | -- |
| Age Group Ave. | .56 | .68 | .69 | .85 | .74 | .77 | .81 | .90 | .97 |
| $\sigma_m$ | .01 | .02 | .02 | .02 | | .01 | .02 | .01 | .01 |
| 10-11 | | | | | | | | | |
| *Desrosier, T. | .67 | .78 | .75 | .70 | .74 | .88 | .84 | .83 | -- |
| Cockburn, A. | .44 | .60 | .59 | .86 | .68 | .90 | .90 | .92 | .90 |
| *Clark, H. | .66 | .63 | .75 | .64 | .69 | .80 | .78 | .78 | -- |
| Ying, M. | .72 | .59 | .75 | .74 | .69 | .88 | .90 | .96 | -- |
| Casella, A. | .63 | .64 | .99 | .70 | .78 | .89 | .99 | .94 | .82 |
| Age Group Ave. | .63 | .67 | .76 | .75 | .73 | .84 | .86 | .85 | .82 |
| $\sigma_m$ | .01 | .01 | .02 | .01 | | .01 | .01 | .02 | .01 |
| 12-13 | | | | | | | | | |
| Briggs, J. | .71 | .59 | .81 | .70 | .70 | .87 | .91 | .94 | .90 |
| *Tucker, E. | .38 | .66 | .39 | .74 | .60 | .90 | .82 | .94 | .83 |
| Domingue, M. | .40 | .77 | .84 | .76 | .79 | .98 | .99 | 1.01 | -- |
| *Cummings, S. | .52 | .59 | .71 | .45 | .58 | .58 | .71 | -- | .69 |
| Age Group Ave. | .50 | .59 | .63 | .66 | .63 | .86 | .86 | .93 | .81 |
| $\sigma_m$ | .02 | .01 | .02 | .02 | | .02 | .02 | .01 | .02 |
| 14-15 | | | | | | | | | |
| Berry, P. | .71 | .56 | .96 | .55 | .70 | .84 | .88 | -- | .88 |
| Holl, E. | .42 | .77 | .82 | .77 | .79 | .81 | .99 | .97 | -- |
| Wing, M. | .60 | .70 | .52 | .51 | .58 | .89 | .77 | .76 | .82 |
| Ovitt, E. | .40 | .39 | .49 | .60 | .49 | .77 | .87 | .85 | .82 |
| Age Group Ave. | .52 | .58 | .66 | .58 | .61 | .80 | .84 | .81 | .81 |
| $\sigma_m$ | .01 | .02 | .02 | .01 | | .01 | .02 | .02 | .01 |
| 18# | | | | | | | | | |
| Blundell, C. | .57 | .55 | .46 | .68 | .56 | .78 | .81 | .87 | .94 |
| Miller, V. | .56 | .58 | .67 | .72 | .65 | .71 | .83 | .79 | .88 |
| Age Group Ave. | .55 | .54 | .56 | .69 | .60 | .71 | .90 | .81 | .86 |
| $\sigma_m$ | .01 | .01 | .02 | .01 | | .02 | .02 | .02 | .01 |
| General Average | .56 | .63 | .69 | .70 | .67 | .83 | .86 | .89 | .86 |

* Classified as partially deaf (Group B)

TABLE IX

Average Durations in Seconds for Dactyl Unit-Groups Using Movements of Hand, Tongue, Jaw, and Breathing Muscles and Containing Syllables for Individual Subjects.

Dactyl 1 - -

| | H | T | J | Br. Mu. | Ave. T,J,& Br. Musc. | Tu | Tus | Stu | Stru |
|---|---|---|---|---|---|---|---|---|---|
| 8-9 | | | | | | | | | |
| *Jack, D. | 1.11 | .86 | .87 | .88 | .87 | 1.02 | 1.13 | -- | -- |
| Casteline, B. | .72 | .79 | .86 | 1.07 | .91 | .99 | 1.11 | 1.18 | 1.42 |
| *Monahan, K. | .60 | 1.01 | 1.23 | 1.01 | 1.09 | 1.15 | 1.24 | -- | -- |
| Age Group Ave. | .77 | .87 | .92 | .96 | .92 | 1.07 | 1.16 | 1.19 | 1.42 |
| $\sigma_m$ | .03 | .03 | .02 | .02 | | .02 | .02 | .02 | .01 |
| 10-11 | | | | | | | | | |
| *Desrosier, T. | .79 | .90 | .87 | .95 | .91 | 1.00 | 1.09 | -- | -- |
| Cockburn, A. | .63 | .89 | .98 | .93 | .90 | .94 | .88 | .87 | 1.16 |
| *Clark, H. | .70 | .80 | .96 | .75 | .84 | .87 | .91 | .80 | -- |
| Ying, M. | .77 | -- | 1.18 | 1.14 | 1.16 | 1.11 | 1.09 | 1.02 | -- |
| Casella, A. | .61 | .73 | 1.01 | .78 | .84 | .87 | .99 | .94 | .89 |
| Age Group Ave. | .71 | .82 | .98 | .94 | .91 | .91 | .98 | .92 | .97 |
| $\sigma_m$ | .01 | .01 | .01 | .02 | | .01 | .02 | .09 | .04 |
| 12-13 | | | | | | | | | |
| Briggs, J. | .78 | .69 | .80 | .84 | .84 | .91 | 1.00 | 1.09 | .96 |
| *Tucker, E. | .63 | .61 | .81 | .79 | .74 | .97 | 1.06 | 1.15 | 1.20 |
| Domingue, M. | .72 | .89 | 1.02 | 1.22 | 1.04 | 1.16 | 1.53 | 1.49 | -- |
| *Cummings, S. | .68 | .71 | .76 | .63 | .70 | .77 | .84 | .77 | .88 |
| Age Group Ave. | .69 | .71 | .76 | .80 | .72 | .81 | 1.03 | 1.02 | .98 |
| $\sigma_m$ | .01 | .01 | .01 | .02 | | .01 | .03 | .03 | .02 |
| 14-15 | .73 | .71 | .96 | .75 | .81 | .92 | 1.05 | -- | 1.08 |
| Berry, P. | | | | | | | | | |
| Holl, E. | .49 | .76 | .69 | .77 | .74 | .93 | 1.19 | 1.06 | -- |
| Wing, M. | .58 | .48 | .76 | .78 | .67 | .85 | .92 | .95 | 1.02 |
| Ovitt, E. | .62 | .64 | .64 | .82 | .70 | .91 | 1.07 | 1.11 | 1.11 |
| Age Group Ave. | .57 | .65 | .78 | .76 | .73 | .87 | 1.01 | 1.01 | 1.04 |
| $\sigma_m$ | .01 | .10 | .02 | .01 | | .01 | .02 | .01 | .02 |
| 18# | | | | | | | | | |
| Blundell, C. | .66 | .73 | .85 | .71 | .76 | .93 | .85 | .93 | .91 |
| Miller, V. | .52 | .82 | .85 | .80 | .82 | .83 | 1.04 | .95 | .97 |
| Age Group Ave. | .54 | .67 | .84 | .74 | .75 | .84 | .93 | .91 | .93 |
| $\sigma_m$ | .01 | .02 | .01 | .02 | | .02 | .004 | .02 | .01 |
| General Average | .67 | .75 | .89 | .83 | .82 | .95 | 1.02 | 1.00 | 1.04 |

* Classified as partially deaf (Group B)

TABLE X

Average Durations in Seconds for Anapaest Unit-Groups Using Movements of Hand, Tongue, Jaw, and Breathing Muscles and Containing Syllables for Individual Subjects.

Anapaest - - 1

| | H | T | J | Br. Mu. | Ave. T,J,& Br. Musc. | Tu | Tus | Stu | Stru |
|---|---|---|---|---|---|---|---|---|---|
| 8-9 | | | | | | | | | |
| *Jack, D. | .98 | .85 | .74 | .92 | .84 | 1.02 | 1.13 | -- | -- |
| Casteline, B. | .67 | .91 | .79 | 1.04 | .91 | .93 | 1.15 | 1.15 | 1.39 |
| *Monahan, K. | .74 | .74 | 1.15 | 1.40 | 1.10 | 1.15 | 1.32 | -- | -- |
| Age Group Ave. | .78 | .84 | .85 | 1.04 | .91 | 1.06 | 1.24 | 1.16 | 1.38 |
| $\sigma_m$ | .03 | .03 | .02 | .03 | | .01 | .03 | .03 | .01 |
| 10-11 | | | | | | | | | |
| *Desrosier, T. | .87 | .94 | .91 | 1.01 | .95 | 1.16 | -- | -- | -- |
| Cockburn, A. | .62 | .87 | .82 | .81 | .83 | .90 | 1.07 | .86 | 1.16 |
| *Clark, H. | .77 | .83 | .82 | .83 | .83 | 1.00 | .90 | .95 | -- |
| Ying, M. | .89 | -- | .85 | 1.05 | .95 | 1.13 | 1.08 | 1.13 | -- |
| Casella, A. | .73 | .79 | 1.13 | .75 | .89 | .88 | .86 | .82 | .80 |
| Age Group Ave. | .74 | .84 | .90 | .87 | .90 | 1.01 | .95 | .91 | .91 |
| $\sigma_m$ | .01 | .01 | .02 | .02 | | .02 | .02 | .02 | .05 |
| 12-13 | | | | | | | | | |
| Briggs, J. | .76 | .75 | .92 | .77 | .89 | .95 | 1.00 | 1.07 | 1.03 |
| *Tucker, E. | .58 | .70 | .58 | .75 | .68 | .90 | 1.08 | 1.15 | 1.24 |
| Domingue, M. | .79 | .97 | .96 | 1.13 | 1.02 | 1.05 | 1.49 | 1.35 | -- |
| *Cummings, S. | .70 | .70 | .72 | .62 | .68 | .77 | .85 | -- | .79 |
| Age Group Ave. | .69 | .73 | .76 | .76 | .74 | .90 | .98 | 1.16 | 1.01 |
| $\sigma_m$ | .01 | .01 | .02 | .02 | | .01 | .03 | .02 | .03 |
| 14-15 | | | | | | | | | |
| Berry, P. | .81 | .63 | .87 | .80 | .77 | -- | 1.09 | -- | .95 |
| Holl, E. | .62 | .90 | .88 | .88 | .89 | 1.02 | 1.31 | 1.25 | -- |
| Wing, M. | .80 | .74 | .69 | .71 | .71 | .93 | .92 | .95 | .87 |
| Ovitt, E. | .54 | .69 | .73 | .72 | .71 | .86 | 1.14 | 1.10 | 1.05 |
| Age Group Ave. | .71 | .73 | .81 | .75 | .76 | .91 | 1.06 | 1.03 | .93 |
| $\sigma_m$ | .01 | .02 | .01 | .01 | | .01 | .02 | .02 | .01 |
| 18# | | | | | | | | | |
| Blundell, C. | .73 | .75 | .85 | .71 | .84 | .91 | .88 | .91 | .85 |
| Miller, V. | .72 | .83 | .79 | .80 | .81 | .78 | .96 | .97 | .95 |
| Age Group Ave. | .71 | .78 | .71 | .74 | .74 | .84 | .89 | .92 | .89 |
| $\sigma_m$ | .01 | .01 | .02 | .02 | | .02 | .01 | .01 | .02 |
| General Average | .73 | .78 | .82 | .82 | .81 | .97 | 1.04 | 1.04 | .93 |

*Classified as partially deaf (Group B)

TABLE XI

Average Durations in Seconds for Phrases: Using Movements of Hand, Tongue, Jaw, and Breathing Muscles, Containing Syllables, and Using Meaningful Words for Individual Subjects.

- 1 - 1 - - 1 - 1

| | H | T | J | Br. Mu. | Ave. T,J,& Br. Musc. | Tu | Tus | Stu | Stru | ** Words |
|---|---|---|---|---|---|---|---|---|---|---|
| 8-9 | | | | | | | | | | |
| *D.J. | 4.23 | 3.62 | -- | -- | -- | 3.93 | -- | 4.47 | -- | 4.97 |
| B.C. | 3.52 | 4.17 | 3.50 | 4.43 | 4.03 | 4.20 | 5.05 | 5.25 | 5.82 | 6.17 |
| *K.M. | 3.97 | 3.31 | 3.46 | 3.25 | 3.34 | 3.93 | 4.66 | -- | -- | 5.11 |
| Age Gr. | 3.74 | 3.63 | 3.28 | 3.88 | 3.62 | 3.89 | 4.72 | 4.60 | 5.70 | 5.43 |
| Ave. $\sigma_m$ | .08 | .10 | .09 | .19 | | .06 | .06 | .08 | .10 | .16 |
| 10-11 | | | | | | | | | | |
| *T.D. | 3.20 | -- | -- | -- | -- | 3.85 | -- | 4.80 | -- | 3.85 |
| A.C. | 3.21 | 3.62 | 3.33 | 3.76 | 3.57 | 4.12 | 4.03 | 4.48 | 5.01 | 4.73 |
| H.C. | 2.99 | 4.48 | 3.34 | 3.72 | 3.85 | 3.46 | 4.71 | 4.38 | 4.60 | 3.57 |
| M.Y. | 4.03 | -- | 3.40 | -- | -- | 3.93 | 5.10 | 4.47 | -- | 5.06 |
| A.C. | 2.94 | 3.88 | 3.52 | 3.56 | 3.65 | 4.25 | 5.20 | 4.90 | 4.55 | 5.52 |
| Age Gr. | 3.19 | 3.71 | 3.24 | 4.17 | 3.71 | 3.87 | 4.61 | 4.47 | 4.59 | 4.87 |
| Ave. $\sigma_m$ | .07 | .06 | .05 | .06 | | .08 | .12 | .10 | .08 | .18 |
| 12-13 | | | | | | | | | | |
| J.B. | 3.25 | 3.07 | 3.12 | 3.58 | 3.26 | 4.10 | 4.52 | 5.43 | 5.60 | 4.76 |
| *E.T. | 3.23 | 3.26 | 3.21 | 2.82 | 3.10 | 3.50 | 3.70 | 3.87 | 3.87 | 4.81 |
| H.D. | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *S.C. | 3.23 | 3.24 | 4.61 | 2.95 | 3.60 | 3.90 | 3.66 | 3.20 | 4.00 | 4.20 |
| Age Gr. | 3.10 | 3.09 | 3.25 | 3.08 | 3.14 | 3.78 | 3.77 | 4.20 | 4.51 | 4.61 |
| Ave. $\sigma_m$ | .05 | .05 | .13 | .08 | | .08 | .11 | .22 | .16 | .06 |
| 14-15 | | | | | | | | | | |
| P.B. | 3.21 | 3.00 | 2.91 | 3.15 | 3.02 | 2.78 | 3.28 | 3.38 | 3.30 | 3.59 |
| E.H. | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| M.W. | 3.36 | 3.87 | 3.81 | 4.42 | 4.03 | 3.58 | 3.97 | 4.16 | 4.06 | 4.12 |
| E.O. | 2.80 | 3.13 | 3.12 | 2.87 | 3.04 | 3.11 | 3.81 | 3.43 | 3.85 | 3.51 |
| Age Gr. | 3.02 | 3.12 | 3.23 | 3.07 | 3.14 | 3.06 | 3.63 | 3.45 | 3.57 | 3.60 |
| Ave. $\sigma_m$ | .06 | .09 | .10 | .14 | | .07 | .10 | .10 | .10 | .10 |
| 18+ | | | | | | | | | | |
| C.B. | 2.94 | 2.34 | 3.35 | 3.16 | 2.95 | 3.89 | 3.51 | 3.94 | 4.07 | 3.43 |
| V.M. | 2.63 | 2.91 | 2.96 | 2.63 | 2.83 | 2.60 | 3.28 | 2.75 | 3.62 | 3.86 |
| Age Gr. | 2.65 | 2.41 | 3.23 | 2.67 | 2.77 | 3.28 | 3.30 | 3.62 | 3.73 | 3.50 |
| Ave. $\sigma_m$ | .09 | .07 | .07 | .08 | | .12 | .04 | .11 | .07 | .09 |
| General Ave. | 3.21 | 3.33 | 3.37 | 3.30 | 3.33 | 3.66 | 4.12 | 4.18 | 4.42 | 4.46 |

* Classified as partially deaf (Group B)

**The stars are bright in the sky at night.

Approved by:

C. O. Sverdrup

Jay R. Fraser

Clarence V. Hedgpeth
Chief Clerk

Date May 13, 1941